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Art. I.—*Observations on Wounds of the Internal Jugular Vein and their Treatment, with Special Reference to the Safety of the Ligature; embracing a Statistical Account of Eighty-Six Cases, with some Remarks upon the General Applicability of Ligation as a Venous Hemostatic Agent.* By S. W. Gross, M. D., late Surgeon and Brevet Lt.-Col. U. S. V.

During the past summer my attention was directed to the subject of wounds of veins and the arrest of venous hemorrhage by the application of the ligature, a procedure that I have been compelled to adopt in five thigh amputations with uniform success. Extending my investigations, it occurred to me to examine more minutely this much neglected branch of surgical pathology, with its attending and resulting accidents, and to publish, possibly, a series of papers on the injuries of special veins, confining my researches to the large trunks of the neck and extremities. Having collected a large mass of facts as a result of that undertaking, this paper, elucidating some points in the surgical pathology of the internal jugular vein, is now presented to the profession as the first attempt that has been made to classify the not very numerous isolated cases of wounds of that vessel. My aim has been to make an impartial examination of all the cases, and deduce from it the most convenient and successful plan of treatment.

The investigation of any statistical inquiry is always attended with more or less difficulty; the more so in the present case, as I was compelled to gain my information by referring to works not under the head of "wounds of the internal jugular vein;" but under the titles of tumours and wounds of the neck, suicide, ligation of the carotid artery, the introduction of air into veins, and hemorrhage. I have had access to the libraries of the

Pennsylvania Hospital, and of the College of Physicians of Philadelphia, the largest collections of medical works in this country; as well as to the carefully selected surgical library of my father, Dr. S. D. Gross, Professor of Surgery in the Jefferson Medical College, of this city. In most instances I have referred to the original papers, and not depended on second-hand quotations. In all cases the sources of information have been mentioned to enable the reader to refer to the author or journal from which they have been gathered; and as I have carefully consulted the medical periodicals of this and foreign countries, it is probable that few have escaped my notice. Several cases, heretofore unpublished, have also been incorporated in the paper.

It is very remarkable that wounds of the veins and venous hemorrhage, subjects replete with deep interest and of the utmost practical value, have been so little treated of, and have, indeed, been so much slighted. This neglect may have arisen from the fact that fatal instances of wounds of large venous trunks are comparatively seldom recorded, and that authors not having the time to devote to the investigation of these topics, remain content to repeat the very meagre and ill-digested accounts of the writers who have preceded them.

We thus find that Mr. Crisp, in his *Treatise on the Diseases of the Bloodvessels*, to which the Jacksonian Prize for the year 1844 was awarded by the Royal College of Surgeons of England, devotes three hundred and eleven pages to the arterial system, including arteritis, aneurism, and wounds; while his chapter on diseases of the veins occupies but twenty-six pages, of which about the same number of lines are given to the consideration of wounds of the veins. The entire chapter is unworthy a position in his admirable essay.[1]

Mr. Hodgson, to whom the Jacksonian Prize for the year 1811 was adjudged, for his *Treatise on the Diseases of Arteries and Veins*, treats of the veins somewhat more fully and satisfactorily than Mr. Crisp. The section on diseases of the veins occupies fifty-six pages, including only inflammation, obstruction, the collateral circulation, and varix. Wounds and hemorrhage are entirely ignored.[2]

Professor Wilson, in his *Lectures on the Blood and Vascular System*, allots eighteen pages to the anatomy and physiology of the veins, and devotes but fourteen to their diseases, namely: inflammation, suppuration, obliteration, varix, varicocele, and hæmorrhoids. He does not mention wounds, and merely alludes to venous hemorrhage, but fully discusses arterial hemorrhage.[3]

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[1] A Treatise on the Structure, Diseases, and Injuries of the Bloodvessels. 8vo. pp. 354. London, 1847.

[2] A Treatise on the Diseases of Arteries and Veins, containing the Pathology and Treatment of Aneurisms and Wounded Arteries. 8vo. pp. 603. London, 1815.

[3] Lectures on the Blood and on the Anatomy, Physiology, and Surgical Pathology of the Vascular System of the Human Body. 8vo. pp. 429. London, 1819.

Mr. Wise, in his *Essay*, treats of wounds of the veins in one page, advising the application of a temporary ligature when it is required. The chapter on the diseases of the veins is rather more full than that on diseases of the arteries, and is a very great improvement on those of the preceding authors.[1]

The statement is very different in regard to wounded arteries and arterial hemorrhage, which have received the attention that their great importance demands. These topics may be found to be fully discussed in all systematic works on surgery, whereas in the very same volumes, injuries of the veins, if alluded to at all, are dismissed in a few paragraphs. In truth the literature of the subject is very meagre; and there are but few papers that can be consulted with any advantage. Of these, by far the most prominent and valuable, although by no means exhaustive, are the essay *On Wounds and Ligatures of the Veins*, by Mr. Benjamin Travers, of London;[2] the chapter *On the Veins*, by Professor Malgaigne, of Paris;[3] *Observations on the Surgical Pathology of the Veins*, by Professor Langenbeck, of Berlin;[4] and the chapters *On the Surgical Affections of the Veins*, by Professor Weber, of Heidelberg.[5]

The Ligature as a Measure for the Arrest of Venous Hemorrhage.—For the arrest of hemorrhage from wounded veins compression is generally advised as the least dangerous, if not the most convenient measure. In regard to the ligature there is a great diversity of opinion, due in later years, in my judgment, to a misunderstanding of the writings of Mr. Travers. The occurrence of a bad form of phlebitis after ligature, wound, or other mechanical injury is conceded by every one to be very uncommon, and in pointing out this fact as well as the origin of the constitutional disturbance attending it, Mr. Travers has narrated cases which have induced the reader to imagine that the accident is really more frequent than it is. As a result of inquiry and experiment, Mr. Travers has merely shown that the serious consequences sometimes following the puncture of a healthy vein, as in venesection, the operations of tying and dividing diseased veins, as varix of the internal saphenous, the complete or partial ligation of healthy veins, or spontaneous inflammation from an inflamed surface in which the vein lies, were due to extensive inflammation of the internal tunic of these vessels. In support of his views he has detailed four fatal cases from venesection, five from ligation of varicose veins, and three from ligation of normal femoral veins. To these predisposing causes he might have added another, namely, the mere exposure of a deep vein during dissection, as in the removal of tumours or the operation for aneurism. From his experiments upon animals he infers that the lining membrane of a vein is susceptible of adhesive inflammation to a very slight extent compared with that of an artery. "Indeed," he remarks of the ligature, "the process of healing and division by ulceration, seem to be conducted without any manifest sign of inflammatory action of the internal tunic;" the obliteration of the vessel being due to interstitial deposits in its coats. Mr. Travers insists on this indisposition of the inner coat to inflame; and that when that process is set up, the inflammation is diffused or continuous. The whole object of his *Essay* is contained in his concluding paragraph, where he says:—

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[1] Essay on the Pathology of the Blood and its Containing Vessels. Second ed. 8vo. pp. 388. Edinburgh, 1858.

[2] Cooper's and Travers' Surgical Essays. 8vo. Part I. London, 1818.

[3] Traité d'Anatomie Chirurgicale et de Chirurgie Expérimentale. Second ed. 8vo., vol. i. chap. x. pp. 306–349. Paris, 1859.

[4] "Beiträge zur Chirurgischen Pathologie der Venen." Archiv für Klinische Chirurgie. Band i. Berlin, 1860.

[5] Handbuch der Allgemeinen und Speciellen Chirurgie. Redigirt von Professors von Pitha und Billroth. 8vo. Bände I.–II. Erlangen, 1865.

> "It is an error to suppose that any quicker sympathy exists between the constitution and venous, than the arterial or absorbent system. I say this because I have observed something like that superstitious alarm, which is excited by events that we do not expect and cannot explain, has been produced by the fatal catalogue of tied veins, and a comparison of this with the generally successful cases of tied arteries. All the mystery of veins is, as I have attempted to show, that they are indisposed to inflame; but when excited, inflame by continuity, and therefore it is that the constitution sympathizes so deeply."

Mr. Travers ascribes the origin of the diffused inflammation to venesection, the ligature or any other local mechanical injury acting upon a *peculiar state of the constitution*. He would, therefore, avoid ligation, as it is not always possible to determine the condition of the blood of a patient upon whom an operation is to be performed. It is thus seen that Mr. Travers has been placed in a false position in regard to the secondary effects produced upon the system by the application of the ligature to a wounded vein. On the second page of his *Essay* he remarks:—

> "I have frequently seen the femoral vein tied without any obvious ill effect; and one of the most experienced and successful operators in the west of England lately assured me that he had been in the constant practice of tying the main vein distinctly from the artery in amputations."

The Ligature an Ancient Procedure.—The ancient surgeons, it must be agreed with Mr. Travers, "treated the veins with singular rudeness—pricking, cutting, tying, and burning them, without ever adverting to any other than the mechanical effects of such operations upon the diseases for which they were instituted." The use of the ligature in early days was empirical, the circulation of the blood in the vessels to which it was applied not being understood. It was supposed that the veins alone carried blood, and that when this fluid was found in the arteries the occurrence was altogether accidental; an error which was, however, pointed out by Galen in the second century. The treatment of hemorrhage from stumps of amputation was, therefore, of the most barbarous description, the red-hot iron being the favourite remedy, together with boiling tar, turpentine, oil, vitriol, and other astringents, until the middle of the sixteenth century, when Ambrose Paré substituted the ligature, which had only been used before his time as an exceptional measure, and one in which little confidence was reposed. To Paré is due the credit of having used a thread to restrain the bleeding from the vessels of an amputated limb, the ligature having been employed exclusively, before his great invention, for the treatment of aneurisms and wounded vessels. It is a great mistake to suppose that the old physicians were not well acquainted with the subject of hemorrhage, and equally as great a misconception to apply the term artery to "*vas*," which simply means a vessel, whether an artery or a vein.

Celsus, who flourished just before the Christian era, distinctly states that for the arrest of bleeding, the vessel is to be tied in two places, and the intermediate portion divided: "Venæ quæ sanguinem fundunt apprehendendæ, circaque id quod ictum est duobus locis delegandae intercidendæque sunt," a precept which was followed for many centuries whenever the ligature was employed. Archigenes, who practised at Rome about the 108th year after the birth of Christ, speaks of sewing the bloodvessels after amputation. Somewhat later, Galen, who was well acquainted with the anastomoses of veins and arteries, advised torsion of the veins, or, if this failed, styptics or obstruents, avoiding the ligature, which would, however, sometimes be necessary. In this practice he was followed by Paulus Ægineta and Aetius. Of the early modern writers, we find that Avicenna, Averrhoes, Rhazes, Haly Abbas, Brunus, Theodoric, Roland, Lanfranc, Albucasis, Avenzoar, Guy of Chauliac, Hollier, Calmetheus, Vesalius, Vigo, Tagaultius, Peter of Argelata, Andreas, Dalechamps, Bertapaglia, Benivieni, Marianus, Bolognini, Ambrose Paré, and many others, strongly advised the ligation of all bleeding arteries and veins, a course of practice which must be considered as a great advance on our own times.

In the eighteenth century, it was the common custom to include the vein with its corresponding artery in the ligature after amputations, or in the operation for aneurism. So general was this procedure that Guattani, in 1772, had to advise separation of the vein and nerve, to guard against the inconveniences ascribed to injury of the nerve alone:—

> "In recommending ligation of the artery alone, without the vein and nerve, I do not think I depart in any way from what is reasonable and right, although I know full well that many high authorities, among whom I may mention the celebrated Mollinelli, are of the opinion that the separation of the vein and nerve from the artery, in the operation of aneurism is of but little, if of any moment." (*Observations on Aneurism.* Translated and edited by J. E. Erichsen. 8vo. p. 271. London: Sydenham Society, 1844.)

It is not generally known that the celebrated John Hunter included the femoral vein in the ligature with the artery in his first three operations for popliteal aneurism. On this subject, M. Deschamps, 1797, also writes:—

> "In the ninth case, I included within the ligature the whole bundle of vessels, that is to say, both the artery and vein. Some doubts have been thrown

upon the advisability of ligaturing veins, but the experience of all ages, as well as anatomical considerations, will serve to remove this imaginary dread. There are no principal veins as there are main arteries; they are so numerous, and their diameter is so great in comparison to arteries, that the return of blood is no way retarded, and I do not think that the surgeon need ever trouble himself about separating the vein from the artery." (Ibid., p. 455.)

During the latter part of the same century, Desault urged ligation of the femoral vein and artery in thigh amputations: "When the two vessels are near to each other, as is generally the case, introduce one leg of the forceps into the artery and the other into the vein; draw them outward at the same time, and secure them by a common ligature. When they are at a distance tie them successively."[1]

Authors of the Nineteenth Century in favor of Ligation of Veins.—Up to 1818, when Mr. Travers published his essay on the veins, but little reference had been made to the supposed dangers of venous deligation. In Great Britain and Ireland, at that time, the procedure was practised to a very limited extent, and the same statement is true at the present date. Professor Velpeau, by his example, did much to dispel the prejudices against the ligature in France, so that it is now regarded as a safe hemostatic agent in that empire. In Germany, Dr. Minkiewicz, Dr. Weber, and Dr. Neudörfer, have shown that the ligature is harmless, and I have been informed by the latter gentleman that its adoption has become almost universal. In this country, the teachings of Professors Mott, Pancoast, Gross, and Stone, have done much to correct the errors existing against its employment, so that it is very generally applied. Since there is a great difference of opinion as regards venous deligation, it may not be uninteresting or uninstructive to record the views of the most prominent authors of all countries, of the present century, in favor of or against the procedure, premising, however, that the ligature is recommended in those cases only in which it is absolutely necessary.

Benjamin Bell, 1804, treating of large wounds of the veins, says: "The same remedy, therefore, should be employed here that we daily use in hemorrhage from wounds in arteries, namely, ligatures; which, when properly applied, never fail to answer the purpose." (*A System of Surgery*, 2d Amer. edit., p. 224. Troy, N. Y., 1804.)

Mr. Hey, 1805, writes: "Having seen a few instances of bleeding from the femoral vein, I generally inclose the vein in the ligature along with the artery." (*Practical Observations in Surgery*, p. 319. Phila., 1805.)

Mr. Chevalier, 1806, says: "I know from experience that the principal vein of a limb may be included in the same ligature as the artery without any disadvantage ensuing." (*A Treatise on Gunshot Wounds*, 3d edition, p. 76. 1806.)

Professor Jameson, 1827, writing of the arrest of bleeding, remarks: "We have had occasionally, in depraved habits, to tie some of the larger veins; we have seen a number of veins pour out blood freely in such habits, and have arrested it by using the crooked needle, by means of which we included in an animal ligature a considerable portion of the surrounding structure, and our experience warrants us in saying that no injury will arise from using an animal ligature in that way, when it may be found necessary." (*Philadelphia Medical Recorder*, p. 37, vol. ii 1827.)

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[1] The Surgical Works of Desault. By X. Bichat. Translated by E. D. Smith, M. D. pp. 476. Philadelphia, 1814.

Baron Larrey, 1829, designedly tied the femoral, the larger branches of the internal saphenous, the brachial, and other veins, for hemorrhage, and never witnessed any accident which could be attributed to their inflammation. In his thigh amputations, he always tied the femoral vein with the corresponding artery, without once seeing any marks of the pretended phlebitis. "We can thus confidently include with the artery their accompanying veins, no matter how large, in spite of the opinions expressed by some physicians." (*Clinique Chirurgicale*, tome iii. pp. 485–489. Paris, 1829.)

Dr. Hennen, 1830, says: "Yet cases will occur, especially in amputation, where the large veins may, under certain circumstances, be secured with a fine ligature, not only without danger, but with advantage; in truth, if there were such imminent danger as has been apprehended, the needle, by which the vein was included in the same ligature as the artery, before the tenaculum came into general use, must have been a most destructive instrument: thousands of successful operations, however, attest the contrary."[1]

M. Sabatier, 1832, remarks: "We should not hesitate to apply a ligature to a wounded vein."[2]

M. Sanson, 1835, would not hesitate to ligate when other means failed.[3]

M. Bégin, 1838, teaches that when large veins are divided in operations, it is almost invariably necessary to tie both ends.[4]

M. Dupuytren, 1839, says: "When the vein is nearly or completely severed, the ligature or compression must be applied between the wound and the capillaries."[5]

Mr. S. Cooper, 1842, writes: "A good deal of blood is sometimes lost from the mouths of the larger veins, and when they bleed much in debilitated subjects, I think Dr. Hennen is right in recommending them to be tied."[6]

M. Nélaton, 1844, says that "the ligature is employed with the same success on arteries and veins."[7]

Mr. Liston, 1846, writes: "Great danger is supposed to accrue from the application of ligatures to veins, and the practice is generally avoided; an open state of their divided extremities, after suppuration is established, is equally, if not more to be avoided."[8]

M. Malgaigne, 1846, says: "All the proceedings applicable to arteries are so also to veins."[9]

Mr. South, 1847, favors the ligature, and writes: "I have tied the femoral vein many times, and in but a single case with ill consequences; the patient had inflammation and pus in the iliac veins, but as this occasionally happens without a ligature having been applied, it may be questioned whether the ligature was the cause of the mischief or not."[1]

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[1] Principles of Military Surgery, p. 151. Philadelphia, 1830.

[2] Médecine Opératoire, tome ii. p. 182. Paris, 1832.

[3] Dictionnaire de Méd. et de Chirurgie Prat., tome iii. p. 231. Paris, 1835.

[4] Nouveaux Élémens de Chirurgie et de Médecine Opératoire, 2d edit., vol. i. p. 376. Paris, 1838.

[5] Leçons Orales de Clinique Chirurgicale, 2d edit., vol. vi. p. 555. Paris, 1839.

[6] Surgical Dictionary, Amer. edit., p. 64. New York, 1842.

[7] Élémens de Pathologie Chirurgicale, vol. i. p. 134. Paris, 1844.

[8] Practical Surgery, 4th edit., p. 21. London, 1846.

[9] Manual of Operative Surgery, translated by Brittan, p. 50 Phila. 1851.

Dr. Chelius, 1847, remarks: "If, however, bleeding from a large vein should continue, it is necessary to tie it; in such cases, for instance in amputations, in which I have frequently tied large veins, I have never observed any symptoms of phlebitis."[2]

Professor Gibson, 1850, is persuaded that the risks of the ligature are greatly exaggerated: "I only mean to imply that there is less danger in tying a vein than is commonly imagined. Influenced by this opinion, I ventured in the case I have related above, to tie the internal jugular in two places."[3]

Mr. Skey, 1851, writes: "I believe the reports of the danger consequent on the application of a ligature around a vein to be greatly exaggerated. In the case of a puncture, however, we have no reasonable alternative but the ligature, and I know of no evidence of any injurious consequences to the vein which would justify us in rejecting it."[4]

M. Sédillot, 1855. says that if large veins continue to bleed, we must have recourse to direct and immediate compression, or include them in a ligature.[5]

M. Richet, 1855, writes: "In very large wounds of the great venous trunks we must ligate."[6]

M. Velpeau, 1856, speaking of hemorrhage from veins of amputated limbs, thinks it would be wrong not to tie them: "The dangers of ligature, upon which so many surgeons have insisted for half a century, are shown to be farthest from the truth, and I should not be surprised to find that it would prove more advantageous to surround them immediately with a ligature, than to leave them free at the bottom of a wound."[7]

Mr. Macleod, 1858, entertains the same opinion as M. Velpeau and Mr. Liston: "It is a question on which it is difficult to decide whether or not, when pus absorption is so common as it was with us, it would not be justifiable practice to ligate the chief vein at the time of the operation. The views of Mr. Travers and others would certainly seem to oppose the adoption of such a step, but we have, on the other hand, the evident absorption of pus into the system by this channel; and, besides, numerous cases are on record in which the ligature of a vein has not only not been followed by evil results, but has absolutely been the apparent cause of preventing inflammation and pus absorption. This is particularly well illustrated in a case related by Mr. Johnston, of St. George's Hospital, in the journals of 1857. In that case those vessels which had been tied were free both of inflammation and pus, while those not included in ligatures were full of pus and 'much inflamed.'"[8]

Mr. Moore, 1860, says: "Pressure is also sufficient to arrest the bleeding from the largest veins divided in amputations; though occasionally, when the loss of blood may seriously affect the issue of the case, it is wisest to tie them."[1]

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[1] A System of Surgery, by J. M. Chelius, M. D., translated by J. F. South, vol. iii. p. 644. Phila. 1847.

[2] Ibid., vol. i. p. 353.

[3] Institutes and Practice of Surgery, 8th edit., vol. i. p. 200. Phila. 1850.

[4] Operative Surgery, p. 198. Phila. 1851.

[5] Traité de Médecine Opératoire, 2d edit., vol. ii. p. 193. Paris, 1855.

[6] Traité Pratique d'Anatomie Médico-Chirurgicale, p. 152. Paris, 1855.

[7] Operative Surgery, 4th Amer. edit., vol. ii. p. 2. New York, 1856.

[8] Notes on the Surgery of the War in the Crimea, p. 395. London, 1858.

Dr. Williams, 1862, writes: "In any case when pressure has failed to restrain hemorrhage from a completely divided vein, a ligature should be applied, first to the lower orifice, and secondly to the upper one, in the event of its bleeding from a retrograde circulation."[2]

Mr. Callender, 1862, in discussing the causes of suppurative phlebitis, makes use of the following emphatic language: "And it often occurs after amputation, as after other wounds; not, however, in consequence of ligatures applied to veins after any such operation. Whether these vessels be tied or not, this inflammation may supervene; indeed in every amputation, as remarked by Blandin, the veins which accompany small arteries are always tied; and we have no right to argue that the ligature of a large vein is more likely to be followed by diffused inflammation of its wall, than is that of the smaller vessels. Such an assumption cannot be justified. Moreover, ligatures separate from veins, as already shown, without exciting inflammatory changes."[3]

Dr. Neudörfer, 1864, says: "It is self-evident that in those accidents, where ligation of a vein is practicable, to do it without hesitation, and without fear, since the danger of exciting phlebitis and pyæmia by ligating a vein is an exploded doctrine with surgeons."[4]

Mr. Solly, 1865, writes: "I can state, from the experience of more than thirty years in this large Hospital (St. Thomas's), that veins may be tied with impunity; but I am also bound to add, that I have seen phlebitis follow the use of the ligature, and a fatal result the sequence, if not the consequence, of the practice."[5]

Dr. Weber, 1865, states that all the measures for restraining hemorrhage from arteries are applicable to the veins, and that the application of the ligature to the veins is free from danger.[6]

Professor Gross, 1866, says: "Great prejudice exists against ligating veins, but experience has shown that the fears that are entertained upon this subject are, if not entirely ill-founded, greatly exaggerated. The largest veins, as the internal jugular and femoral, have repeatedly been tied with impunity. I have myself never hesitated to adopt this treatment when occasion seemed to demand it."[7]

Authors of the Nineteenth Century Opposed to the Ligation of Veins.—*M. Roux*, 1813, states that "if compression is insufficient to arrest the hemorrhage, it will be necessary to ligate the vein, an event, when practised, even more to be feared."[8]

Mr. Travers, 1818, is opposed to tying veins, as it sometimes gives rise to a diffused and fatal inflammation of the inner coat of the vessels.[9]

Mr. Allan, 1821, has seen the axillary vein cut and ligated in two instances of removal of tumours from the axilla. In one of these death ensued, on which account, he says: "I apprehend that the ligature should never be employed in wounds of the veins; more especially as the hemorrhage may always be easily suppressed by compression, either without or within the wound."[1]

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[1] A System of Surgery, edited by T. Holmes, vol. i. p. 695. London, 1860.
[2] Costello's Cyclopedia of Practical Surgery, vol. ii. p. 528. London, 1862.
[3] A System of Surgery, by T. Holmes, vol. iii. p. 303. London, 1862.
[4] Handbuch der Kriegschirurgie, p. 69. Leipzig, 1864.
[5] Surgical Experiences, p. 279. London, 1865.
[6] Handbuch der Allgemeinen und Speciellen Chirurgie. Redigirt von Profs. Von Pitha und Billroth, vol. i. p. 166. Erlangen, 1865.
[7] A System of Surgery, 4th edit., vol. i. p. 511. Phila. 1866.
[8] Nouveaux Élémens de Médecine Opératoire, vol. i. p. 249. Paris, 1813.
[9] Loc. cit., ut ante.

M. Lisfranc, 1845, has seen ligation of veins so often followed by phlebitis that he is very doubtful of the safety of the operation.[2]

Mr. Crisp, 1847, speaking of division of the veins, says: "Dangerous and fatal hemorrhage will sometimes take place from this cause, and it is occasionally necessary to have recourse to the ligature. It must be recollected, however, that the veins are more prone to diffused inflammation than the arteries, and on this account the use of the ligature should be avoided if possible."[3]

Mr. Wise, 1859, is opposed to the usual manner of ligating a vein by division of its outer coat, lest the dangerous irritation of its lining membrane be increased, and he proposes flat ligatures to approximate the sides of the vessels, which are to be removed in a few hours, or at the first dressing. (*Op. cit.*, p. 369.)

Dr. Günther, 1859, believes the ligation of large veins to be injurious, as it may excite phlebitis, and, through it, pyæmia.[4]

Dr. Langenbeck, 1860, evidently thinks the ligature is to be avoided whenever it is possible, particularly in crowded hospitals, where the danger from thrombosis and pyæmia is increased; although he has narrated three examples of the procedure as applied to the internal jugular vein, he would, as a rule, avoid it. (*Op. cit.*)

Mr. Porter, 1863, says: "Surgeons in this country are not favourable to the practice of ligaturing a vein, although having the sanction of such authorities as Hey, Desault, and Hennen. The dangerous, and sometimes fatal phlebitis, following such procedure, has given us a wholesome dread of tying or in any way inflicting injury on these vessels."[5]

Mr. Miller, 1864, writes: "By every means in our power, we ought to avoid deligation of a vein. For, as will afterwards be seen, a form of phlebitis ensues, which, especially in its higher grade, is apt to spread; and, therefore, it need be no matter of surprise to find the very worst results of that disease supervening on the application of a ligature to a vein."[6]

Mr. Erichsen, 1864, says: "If the vein be one of considerable size, as the internal jugular; or if it be so situated that pressure cannot be brought to bear on it, it may require the application of a ligature; but this should, if possible, always be avoided, inasmuch as it is apt to occasion dangerous inflammation of the vessel."[7]

Mr. Pirogoff, 1864, is much opposed to the ligature, and remarks: "Suffice it to say that I have lost all my patients from pyæmia in whom I, and other surgeons in my presence, have been compelled to tie the femoral or axillary veins."[8]

It thus appears that there is a great difference of opinion among the authors whom we have mentioned as to the applicability of the ligature for the suppression of venous hemorrhage. The majority are in favour of the procedure, and the list might be largely increased, if we were to include those who advocate the operation in cases where compression is inapplicable, or death seems to be impending from alarming loss of blood. This difference of opinion may be due, in some measure, to an imperfect examination of the subject, very slight experience, or to prejudices in favour of or opposed to the procedure. The true reason, however, seems to depend upon a difference of sentiment in regard to the cause of pyæmia, which accident those authors, who are opposed to the measure, appear to fear most. The dangers of a fatal issue from this cause are, I am fully convinced, from a very extended investigation of the cases of ligation of veins, very greatly exaggerated, and I am sure that the surgeons who consider this accident as the most frequent cause of death, have either not examined the subject, or, at best, only very superficially, exhibiting that tendency, unfortunately too often seen to the detriment of the progress of science, in our profession, to adopt the opinions of men who justly hold a prominent position.

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[1] A System of Pathological and Operative Surgery, vol. ii. p. 432. Edinburgh, 1821.

[2] Précis de Médecine Opératoire, vol. i. p. 94. Paris, 1845.

[3] Op. cit., p. 334.

[4] Lehre von den Blutigen Operationen am Menschlichen Körper. Erste Abtheilung, p. 55. Leipzig und Heidelberg, 1859.

[5] Dublin Quarterly Journal, Nov. 1863, p. 269.

[6] A System of Surgery, p. 229. Edinburgh, 1864.

[7] Science and Art of Surgery, p. 154. London, 1864.

[8] Grundzüge der Allgemeinen Kriegschirurgie, p. 440. Leipzig, 1864.

Phlebitis and Pyæmia as assumed Dangers.—It is not my purpose to enter into any extended inquiry into the various theories of the pathology of pyæmia, as the investigation of the subject would require too much space, and would be out of place. Suffice it to say that I regard the affection known as pyæmia as a zymotic disease, having for its exciting cause a vitiated condition of the blood, due to the introduction of a septic poison into the system, which may be called into action, and evince its peculiar phenomena from a great variety of secondary causes. It is just on this point that authors are not agreed, and it must, therefore, be expected that as long as primary phlebitis is held by many surgeons to be the cause of pyæmia, instead of the effect, just so long will they withhold the ligature for fear of exciting diffused or purulent phlebitis. The healthy, or adhesive inflammation of Mr. Hunter, such as is produced by the ligature, is an unimportant and perfectly innocent affection, just as necessary to the closure of a wounded or tied vein, as to the same conditions of an artery. The inflammatory action has for its object the formation of a clot and its adhesion to the inner wall of the vessel; and even when it oversteps this limit, it is often seen to be circumscribed by deposits of lymph, giving rise to an abscess within the walls of the vessel, which is thus cut off from the general circulation. I cannot agree with Mr. Travers, Mr. Callender, and other observers, that the thread acts "without exciting inflammatory changes." How else are we to account for the injection and redness of the outer coats, the deposition of serum and lymph, the death of the portion of the vessel included in the ligature, and its subsequent separation by ulcerative action? If these authors mean to confine their statements to the lining membrane of the vein, I think they are correct, as numerous observations and experiments have proved that it is difficult to produce marks of inflammatory action in that tunic. It may then be concluded that the changes take place in the external cellular tunic, and to a lesser degree in the middle coat, with, as Dr. Mackenzie thinks, an irritated state of the lining membrane.

Assuming, then, that unhealthy or suppurative phlebitis and its secondary effects depend upon a vitiated state of the blood, we are able to appreciate how it is that those affections may follow various dissimilar injuries, and reconcile the infrequency of their occurrence after operations involving the venous system. The dangers are not to be looked for when the general condition of the system of the individual is good, and when the walls of the vessels are in a healthy state; but they may be anticipated in enfeebled and broken-down constitutions, more particularly when the coats of the vessels are abnormally changed. Upon such a class of persons operative procedures should, therefore, if possible, be avoided.

The causes which predispose to the occurrence of phlebitis and pyæmia are those which favour the development of an enfeebled condition of the system, and a vitiated state of the blood, which shows a tendency to coagulate in the vessels. Thus bad food, exposure and scurvy, peculiar states of the atmosphere, the impure air of crowded hospitals, the puerperal state in feeble and nervous women, and certain protracted diseases, as gangrene, phthisis, Bright's disease of the kidney, and typhoid fever, strongly favour their occurrence. Of the traumatic causes, the most common are operations upon the bones and joints, injuries of the head, the shock and exhaustion following profuse loss of blood in surgical operations, and serious and extensive injuries. The extension of unhealthy inflammation from lacerated wounds, comminuted fractures, and wounds made in operative procedures, from the slightest puncture, as that made in phlebotomy, to the largest incisions, also favour their development. Mr. Guthrie considered that pyæmia was the most frequent cause of death after amputation. It may also arise from an abscess discharging its contents into an ulcerated vein, several examples of which accident connected with the internal jugular vein, are on record. In a very interesting paper entitled *A Pathological Inquiry into the Secondary Effects of Inflammation of the Veins*, Mr. Arnott has narrated ten fatal cases of pyæmia following venesection; two from wound of the femoral vein in the operation for popliteal aneurism; one after division, and one after excision of a portion of a varicose vein; and three after thigh amputations, in only one of which was a ligature applied to the femoral vein. The post-mortem examinations showed pus, or pus with lymph, in the vessel in fourteen instances; in two lymph was present, but no mention is made of pus; and in one neither fluid was apparent. Pyæmia and metastatic abscesses were also the causes of death in thirty-seven cases of injury of the head, the majority of which were attended with fracture or loss of portions of the bone. Mr. Arnott, therefore, concludes that "these considerations show that the secondary effects of phlebitis are connected with a vitiated state of the circulating fluid; a further proof of which may be found in the yellow colour of the skin, so constantly observed in cases of this disease."[1]

An altered state of the blood, and not the existence of primary phlebitis, must then be regarded as the starting point of these morbid changes; and in idiopathic cases the spontaneous coagulation of the blood gives rise to secondary phlebitis and to mestastatic abscesses in the different tissues and organs of the body. By the application of a ligature to a vein, or in any of the operations for varicose veins, either by caustics, compression, or by subcutaneous ligation or division, we cause a coagulum to form as a result of mechanical irritation of the vessel itself; and coagula also form whenever a vein is partially or completely divided, without the application of a thread. Upon the quality of these concretions will depend the issue of each case. Thus if the fibrin be deposited from an impoverished or morbidly altered blood, these clots will soften and become broken down into a puriform fluid, which will give rise to a train of symptoms denotive of the occurrence of pyæmia, or of acute phlebitis. From the fact of the disintegration commencing at the centre of the clots, additional evidence is afforded of the blood, and not of the walls of the vein, being the origin of the disease. If, on the other hand, the clot be the result of irritation of a vein occurring in a person in whom the circulating fluid is healthy, the worst event that can follow will be simple obstruction or obliteration of the cavity of the vessel.

The Ligature, if properly applied, not the Cause of Pyæmia.—The most common predisposing causes of pyæmia are the slight puncture made by the lancet in venesection, the extension of inflammation from unhealthy stumps and wounds into open veins, and operations on the veins and on the bones in which the venous orifices are patulous. The ligature has also been accused of being productive of the same occurrence, and it, therefore, becomes a very important inquiry whether it has any agency in the mortality of operations. From the preceding considerations of the pathology of phlebitis—and for further information on this subject, the very interesting work of Mr. Henry Lee,[2] and the contributions of Mr. G. W. Callender,[3] may be consulted—it is seen that the formation of a clot is sometimes the consequence and sometimes the cause of phlebitis, the former depending on a vitiated blood, the latter on irritation of the vessels; and that the subsequent changes in the clot determine the morbid phenomena. It is not, however, to be inferred that the coagula are always necessary to the production of pyæmia, or the healing process of wounded veins, since they are sometimes altogether absent. The clot of a ligated vein is more delicate and smaller than that of a divided vein, and it is the extension of the clot into the latter that so often proves the source of pyæmia after amputations. After a very careful examination of the whole subject, *I do not hesitate to state that the occurrence of pyæmia, when of traumatic origin, is due to the wound of the vessel itself, and not to the ligature; that a predisposition to the disease, or, rather, a peculiar morbid condition of the blood, is necessary for its development; and that when that predisposition exists, the affection may show itself whether the vein has been tied or not: in other words, when the coats of the vessel are healthy, and the condition of the blood is normal, the ligature is never the starting-point of pyæmia.*

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[1] Medico-Chirurgical Transactions, vol. xv. p. 61. London, 1829.

[2] On Diseases of the Veins, Hæmorrhoidal Tumours, and other Affections of the Rectum. Second edition. London, Churchill, 1866.

[3] A System of Surgery. Edited by T. Holmes, vols. i. iii. London, 1860–1862.

In making this assertion—the "exploded doctrine" of Dr. Neudörfer—I am aware that I shall meet with much opposition, and be expected to support my views by facts. By referring to "Table No. I." "Fatal Cases of Wounds of the Internal Jugular Vein," it will be seen that twelve cases were fatal secondarily, five from hemorrhage, *five from pyæmia*, and two from other causes, and that in none of the cases was any mode of treatment adopted, much less the ligature. On referring to "Tables II. and III." it will be seen that the same vein was ligated in forty-one instances, and that the deductions are based on forty cases, in which the results are known. Death is referable to the employment of the ligature in five cases only, and of these four were carried off by secondary hemorrhage, and *but one by pyæmia*, and in that case no post-mortem examination was held, so that it really proves nothing. Let it be added that the ligature was required in all the cases to prevent death either from the loss of blood or from the introduction of air, and that the vein was wounded in twenty-eight of the cases in the removal of tumours of the neck. May it not, then, fairly be concluded that the ligature had nothing to do with the fatal case of pyæmia, but that the operation itself was the cause of death; showing the very remarkable result of mortality from pyæmia in the extirpation of tumours of the neck of only 3.57 per cent.

I have also collected fifteen cases of ligation of the axillary vein, and twenty of the external jugular—and the list could have been much extended—without one death from pyæmia. The conclusion has, therefore, been forced upon me that *the ligature must be excluded from the category of the predisposing causes of pyæmia.*

The Ligature as a Means of Preventing the Extension of Unhealthy Inflammation.—On reviewing the opinions of the authors not opposed to tying veins, one cannot fail to be struck with certain expressions showing that the ligature is not only not to be avoided, but that its use is indicated, when pyæmia prevails epidemically, or when the elements of that affection are supposed to pre-exist in the system of the individual. Dr. Hennen states that large veins may be tied, not only without danger, but with advantage. After suppuration of a wound had taken place, Mr. Liston feared an open state of the divided extremities of veins much more than when a thread had been applied. M. Velpeau says that he would not be surprised to find that it would prove more advantageous to surround the divided veins immediately with a ligature than to leave them open at the bottom of a wound. Mr. Macleod, writing of the mortality of amputated cases from pyæmia in the Crimea, questions whether it would not be better to tie the chief vein of amputated limbs, to prevent the evident absorption of pus by that channel. Numerous recorded cases, he remarks, show not only no ill effects from the procedure, but that it has absolutely been the apparent cause of preventing inflammation and the absorption of pus. The frequency of pyæmia after amputation is attested by the experience of all surgeons. Mr. Bryant gives it as the cause of death in 42 per cent. of all fatal cases of amputations, and in 10 per cent. of all amputations, the observations having been based upon 300 cases.[1] If the changes preceding the appearance of the signs of systemic infection are to be looked for in the clot in the interior of the vessel, it is of primary importance to induce a coagulum of small size. The clot which extends into the open extremity of a divided vein of a stump is larger than that produced by the application of a ligature, so that the latter expedient would seem to be indicated. This is particularly well seen in the case of Mr. Johnston, quoted by Mr. Macleod, in which "*those vessels which had been tied were free both of inflammation and pus, while those not included in ligatures were full of pus and much inflamed.*"

The extension of local inflammation to neighbouring veins when a ligature has not been used is well shown in the table of fatal wounds of the internal jugular vein, before referred to. Pyæmia was the cause of death in 25 per cent. of all the cases, and in 41.66 per cent. of all the cases secondarily fatal. In all, abscesses had formed about the sheath of the vessels. In Case XIV. the small veins in the neighbourhood of the abscess were filled with broken-down coagula. In Case XVI. there was an abscess of six ounces' capacity between the vertebral column and the sheath of the vessels, and the vein showed marks of high inflammatory action. An abscess had also formed in Case XVII. behind the vessels, and the post-mortem inspection on the fifteenth day after the injury indicated a round opening in the internal jugular vein, two lines in diameter, and the cavity of the vessel occupied by a broken-down clot. It is proper to add that in this case M. Tacheron would have applied a ligature, had it been possible to do so. In Case XVIII. the wound was open, the coats of the vein were infiltrated with lymph, and the interior filled with fibrin, while the neighbouring veins showed the effects of phlebitis. By contrasting these cases in which the ligature was withheld with those in which the jugular vein was tied, it may fairly be assumed that *the ligature may prevent diffused inflammation of the walls of a vein and the phenomena included under the general term of pyæmia.*

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[1] "On the Causes of Death after Amputation." Medico-Chirurgical Transactions, vol. xxiv. 2d Series. London, 1859.

In the preceding considerations, which refer to the safety of the ligature when properly applied, I have endeavoured to show that venous deligation is not to be avoided from the fear of exciting pyæmia. I have now to consider some of the causes which may produce that affection, under unfavourable circumstances, in the case of the internal jugular vein.

The Ligature Improperly Applied as a Cause of Diffused Phlebitis.—In the operation for aneurism it occasionally happens that the accompanying vein is transfixed by the aneurism needle, and if the mistake be not discovered, and the ligature withdrawn and applied at another point, it will act as a seton within the cavity of the vessel, and induce the train of symptoms referable to diffused phlebitis and the production of systemic infection. A number of such fatal cases are on record, in which the femoral vein has been pierced in the Hunterian operation for popliteal aneurism. The following cases of death from wounds of the internal jugular vein were evidently due to this accident producing pyæmia, although it is not so stated by Mr. Arnott in his paper "On the Secondary Effects of Inflammation of the Veins," before mentioned, nor by Professor Van Buren, of New York, in the second case.

CASE I.—"A young man had a ligature placed on the left carotid artery for an aneurismal disease of one of its temporal branches. Considerable difficulty was experienced in passing the needle round the vessel. Venous hemorrhage took place during the operation, recurred at night, and occasionally afterwards, for nine or ten days. On the fifth day after the operation, the patient had a severe rigor, succeeded by heat of skin and general febrile symptoms. These increased, the pulse rose to 120, and the constitutional disturbance assumed a very violent character. About the tenth day, the vision of the left eye became impaired, and was quickly lost, the pupil was contracted, the iris immovable, and the cornea had a somewhat hazy appearance; effusion took place under the conjunctiva, and the eyelids were greatly swollen, giving the appearance of the globe being much protruded; at the same time, there was a degree of deafness, considerable stupor, with occasional slight delirium. In the course of a few days the coats of the eye sloughed at the upper part, and its contents were evacuated. Whilst these changes were occurring in the eye, collections of matter formed without pain in different parts of the body, on both shoulders, above the insertion of the deltoid muscles, over the sacrum, &c. The constitutional disturbance abated, the collapsed eye healed over, but he never recovered his health. Five months subsequently he died, labouring under lumbar abscess, and worn out by hectic. On examination of the body, at which I was present, a portion of the jugular vein, to the extent of two inches, was found wanting; the upper and under extremities being shrunk, ligamentous, and gradually lost in the cellular substance. On opening the head, pus was found effused in great quantity between the tunica arachnoidea and pia mater, along the base of the brain, and the whole length of the spinal cord. The inter-muscular cellular substance of the loins was loaded with pus. The viscera of the abdomen and chest were not examined."

CASE II.—A man, twenty-five years of age, entered the New York Hospital, with exophthalmia of the right eye, due to a pulsating encephaloid tumour of the orbit. On the 10th of May, 1857, Professor Van Buren tied the primitive carotid artery, and for a week every symptom promised well. On the eighth day, severe rigors occurred, followed by quick pulse, hot skin, sweats, prostration, and other evidences of pyæmia. The wound opened, and a thick, chocolate-coloured fluid was discharged, with occasional expulsion of large clots of blood on coughing. This continued until the death of the patient on the thirteenth day after the operation. On examination of the body, the wound presented a cavity of almost double its original extent; its walls were formed by dark sloughy tissue, "and at its bottom the ligature was found still slightly attached to what seemed to be a portion of the sheath of the vessels, the carotid artery having been entirely cut through, and its divided extremities retracted from each other to the distance of three-fourths of an inch." The artery was closed at both extremities, but "at a point opposite to the attachment of the ligature, and for the space of an inch in extent, the internal jugular vein was open, so that the handle of the scalpel could be readily passed into the vessel upward and downward; its coats having been destroyed throughout nearly half of its circumference by ulceration or sloughing." This lesion explained the symptoms of pyæmia, and the source of the discharge of clotted blood. "On examining the thoracic viscera, several abscesses as large as English walnuts were found in the substance of each of the lungs, and a number of smaller ones on their surface." (*New York Journal of Medicine*, July, 1857, p. 48.)

The mere Exposure of a Vein as a Cause of Diffused Phlebitis.—Another occurrence, fortunately infrequent, which may give rise to diffused phlebitis or pyæmia, is the laying bare of large deep veins, without any injury whatever to their coats, or the production of a mere bruise. On this subject, M. Broca, referring to the dangers of the operation for aneurism, writes:—

> "Another accident, less frequent, but more serious than secondary hemorrhage, is purulent phlebitis of the vein which accompanies the ligated artery. This vein, often bruised during the operation, remains denuded at the bottom of a wound in which suppuration is almost inevitable, and it is easy to understand, under such circumstances, that it frequently becomes inflamed. Phlebitis is a very serious complication in itself, and much more so in the present case, because it is generally seated in a very large vein. When it becomes purulent, it gives rise to a purulent infection which is soon fatal; and when it is limited to obliteration of the vein by clots, it opposes to the circulation of the limb, already compromised by ligature of the artery, a new obstacle, which favours the production of gangrene." (*Des Anévrysmes et de leur Traitement*, p. 478. Paris, 1856.)

A case, of which the following is an abstract, demonstrating the truth of the remarks of M. Broca is narrated by Dr. James R. Wood, of New York, in his very interesting paper, "On Ligature of the Common Carotid Artery." Professor Post tied the common carotid for a large subcutaneous erectile tumour of the cheek. "In opening the sheath of the vessels, the deep jugular vein was not exposed. The patient appeared to be doing well for several days after the operation, after which he had rigors, with low delirium and irritative fever. He died, as nearly as I recollect, about the eighteenth day after the operation. On making the autopsy, the deep jugular vein accompanying the artery which had been tied, was found inflamed with pus in its cavity." (*New York Journal of Medicine*, July, 1857, p. 42.)

The following cases, presenting remarkable points of similarity, also bear directly upon the observations of M. Broca:—

Case I.—Professor J. C. Warren, of Boston, removed the right clavicle for osteo-sarcoma. The subclavian vein was exposed in the whole extent of its course, as was also the lower third of the internal jugular. On the thirteenth day, the patient was seized with chills, the pulse rose from 80 to 112, he suffered from great nervous agitation, and was slightly delirious. Death ensued on the 28th day. The post-mortem inspection showed the subclavian and jugular veins and the upper portions of the axillary and cephalic veins blocked up with firmly adherent coagula. The right pleural apex corresponding with the wound was covered with lymph, but the membrane was uninjured. The lower edge of the right lung was also the seat of lymph deposits, and the effusion was more considerable on the left side, with two or three spots nearly an inch in diameter, in the substance of the lung. The left pleural sac contained sanguinolent fluid. (*American Journal of the Medical Sciences*, Nov. 1833, p. 17.)

CASE II.—Professor Langenbeck removed the left clavicle for fibroid disease. The subclavian and internal jugular veins were exposed, and the former vessel was dissected off with difficulty. On the third day the patient, after a bad night, was seized with chills, and the pulse rose to 130. On the fifth day he was very restless, the intellect was clouded, the respiration short and quick, and he rapidly sank. The internal jugular vein was found to be occupied by a long, slightly adherent thrombus. The left pleura was not wounded during the operation, but was thickened by yellowish gray effused lymph, and the sac contained a very copious lymph exudation. (*Arch. für Klinische Chirurgie.* Band I. p. 8. Berlin, 1860.)

The True Danger from Ligating a Large Vein.—It is to be observed from the foregoing remarks that I have endeavoured to place the subject of venous deligation in its proper light, and demand for the ligature the same recognized position as a venous hemostatic agent, that it has acquired for the arrest of arterial hemorrhage. I have also, I think, adduced sufficient evidence, based upon tying the largest vein in the system to which surgical remedies are applicable, to prove that the fears of the production of diffused phlebitis, so much insisted upon by some authors, and so readily acquiesced in by a portion of the profession, are groundless. I have shown that pyæmia has resulted in but one case of the extirpation of a tumour of the neck in which the internal jugular vein was tied, and that the vein has been tied forty-one times; and also that pyæmia has followed five wounds of the internal jugular, for which there was either no treatment adopted, or the plan of treatment is not mentioned; that the same affection carried off two cases in which the vein had been transfixed by the thread in tying the common carotid artery; and, finally, that it was the cause of death in three operations in which the vein was simply exposed, a thrombus being present in the vessel in every one.

Since, then, pyæmia is not to be regarded as a cause of death after tying a vein, it may be asked what is the real danger attending the procedure? To this I answer it is precisely the same as that which results from arterial ligation, namely, *secondary hemorrhage*, coming on about the time of the separation of the thread. So preoccupied do authors appear to have been with the assumed danger of diffused phlebitis that they have not even mentioned secondary hemorrhage as a cause of death, and I was myself not at all aware of its frequency as a source of mortality, until I undertook the present investigation, which shows it to be eighty per cent. of all the fatal cases referable to the ligature.

The other dangers and inconveniences from tying veins are connected with the state of the collateral circulation, and include gangrene below the seat of the ligature, apoplexy, softening of the brain, and other cerebral disorders, œdema, and dropsical effusions. The head affections will be alluded to in this paper, while the other dangers will be considered at a future time.

Wounds of the Internal Jugular Vein.—The internal jugular vein, continuous above with the lateral sinus, collects the blood from the interior of the cranium and the greater part of the head and neck. At its origin there is a dilatation, known as the sinus of the vein, and it is here closely adherent to the jugular fossa. Opposite the larynx its capacity is the greatest, the enlargement being the consequence of its having received several large branches; and it becomes somewhat contracted below, where it empties into the innominate vein. Upon its anatomical structure and relations, therefore, will depend the gravity of wounds inflicted upon it. The walls of the vessel are comparatively thin, its capacity is large, and the flow of blood through it is influenced by gravitation and by the absence of valves, so that there will be considerable regurgitation below.

If the vessel be divided in the inferior third of its course, the orifices will remain open, and its walls not collapse, owing to their connection with the deep cervical fascia, and here the danger to life from reflux bleeding and from the introduction of air, is greatest, the hemorrhage being more copious from the central or cardiac end during natural expiration, and during the convulsive motions of the expiratory muscles, as in crying, sneezing, and coughing. The introduction of air will take place during inspiration. Division of the vessel in its middle and upper thirds is not attended with equal danger, as the influence of the respiratory movements is not as much felt, and the walls of the vein have a tendency to fall together. Hemorrhage in these cases will occur from the peripheral or distal divided end, little, or no blood at all, flowing from the central extremity.

Should the vessel be injured near the base of the skull, fatal bleeding will ensue, provided there be a free external outlet; a recovery from a wound in this situation has not been recorded. It should also be taken into consideration that this vein, in common with the venous system at large, possesses very feeble contractile powers; and also that the capacity of the veins increases with age; so that, if wounded, the loss of blood will be greater in old persons and in debilitated constitutions, as in these conditions the capacity of the veins is much increased, whilst the arterial capacity is in a corresponding degree diminished.

From the above considerations it is to be observed that wounds of the internal jugular vein must be classed among the most dangerous and fatal of accidents. *Provided there be a free external opening for the escape of blood, they are equally as formidable as corresponding injuries of the* *carotid artery.* In the latter case, should instantaneous death not ensue, the formation of a protective clot will be favoured by a state of syncope and by the contraction and retraction of the coats of the vessel. In the case of the jugular vein, fainting does not very materially assist coagulation, and the vessel does not contract. Add to this the dangers to life from the aspiration of air, the occurrence of phlebitis and pyæmia, with the following results, and my statement will prove to be correct. Cases of recovery from gunshot injury of the carotid artery are on record; but I have been unable to find a single example of similar lesion of the internal jugular vein attended with so happy a result. On the contrary, all the cases have proved fatal; 62.5 per cent. from secondary hemorrhage, 25 per cent. from pyæmia, and 12.5 per cent. from primary hemorrhage. All incised or punctured wounds, *not made by surgeons in operations*, have likewise ended in death; 50 per cent. from primary hemorrhage, and 50 per cent. from pyæmia. Of suicidal wounds there are eight examples, with two deaths and six recoveries; but of the latter, the ligature was employed in four, compression in two. The aspiration of air was the cause of death in four cases; the results of all other cases will be given under the head of treatment.

Wounds of the internal jugular do not differ from wounds in other tissues as regards the weapons with which they are inflicted, and may be incised, contused, punctured, lacerated, or gunshot. They are most commonly made by the surgeon in the extirpation of tumours of the neck; as in many of these cases the vein will be found to be intimately attached to the morbid growth, or imbedded in it, or displaced from its normal position, thus rendering it very liable to be opened. If the precaution be not taken to tie or compress the wounded vein, alarming hemorrhage, or death from the introduction of air, may ensue. Any one who has been unlucky enough to puncture or divide the vessel, cannot have failed to have been struck by the copious and embarrassing bleeding, and the difficulties of applying a ligature, particularly in the upper part of the neck.

Injuries of this vessel have occupied the attention of surgeons from time immemorial; and yet it is strange how few cases have been reported. Paulus Ægineta treats of them. Ambrose Paré, in his Chapter on "Wounds of the Neck," written upwards of three hundred years ago, says:—

> "Celles des veines jugulaires et arteres carotides, estans grandes, sont mortelles, pource qu'elles ne peuvent estre estreintes et comprimées par ligatures, à cause que le col ne peut estre fort serré, qui l'on ne suffoquast le malade: au moyen de quoy s'ensuit un flux de sang, qui est cause de mort." (*Œuvres Complètes d'Ambrose Paré.* Par J. F. Malgaigne. Vol. ii. p. 90. Paris, 1840.)

And yet Paré narrates three cures by compression, which will be given in their proper place.

Dr. HENNEN, treating of injuries of the neck, uses the following language:—

"I omit saying anything on wounds of the jugulars, or carotids; gunshot openings of them I hold to be so universally fatal that any exceptions may be looked upon as merely serving to confirm the general rule. (*Principles of Military Surgery*, p. 286. Phila., 1830.)

As I have shown, Dr. Hennen was perfectly correct in this opinion; but the statement of Professor Boyer is remarkable:—

"When the large veins of the thoracic or abdominal cavities, and the internal jugular are wounded, the injury is beyond the resources of art and the patient dies of hemorrhage. Death has also supervened in the cases in which the internal jugular has been tied." (*Traité des Maladies Chirurgicales*, 5th edit., vol. ii. p. 422. Paris, 1845.)

The above statement of Professsor Boyer—and it occupies about as much space as authors generally devote to this injury—is perfectly gratuitous, and liable to mislead the reader. It is the more astonishing, as, at the time the sentence was written, not less than fifteen successful cases of ligation of the internal jugular had been reported, as well as several cures by compression.[1]

The following fatal cases, in which no treatment was employed, or the treatment is not mentioned, are separated into different classes for greater convenience of reference.

I. *Cases of Death from Primary Hemorrhage.*—The number of recorded cases of death from primary hemorrhage is very small, the following being the only ones that I have been able to discover:—

Case I.—M. Vallée saw a soldier who had been stabbed in the neck, the right internal jugular vein being almost completely divided. The edges of the wound were retracted and the vein was empty. Death was almost instantaneous. (*Gazette Médicale*, p. 267. 1837.)

Case II.—Mr. Bryant reported to the Pathological Society of London the case of a girl, nine years of age, who, one hour previous to her admission into Guy's Hospital, Nov. 1st, 1856, whilst carrying a chamber utensil in her hand, stumbled, and fell on the broken china. She bled freely at the time, and no other means than the application of adhesive plaster had been adopted. On admission she was pulseless and dying. There was a cleanly cut wound on the right side of the neck, one inch long and one inch external to the thyroid cartilage. There was no bleeding, but the child died in five minutes. On inspection it was found that the sharp edge of the broken china had made a clean V-shaped incision of the outer wall of the internal jugular, one-fourth of an inch in extent. (*Trans. of Path. Soc. of London*, vol. viii. p. 101. 1857.)

Case III.—"During the summer of 1859, one of the inmates of St. George's Hospital committed suicide by cutting her throat. She was almost immediately seen by the house surgeon, but had already ceased to breathe, and was quite pulseless. There was a deep gash in her throat, dividing the left common carotid artery, and wounding both internal jugular veins." (Mr. Henry Gray. *Holmes' System of Surgery*, vol. ii. p. 277. London, 1861.)

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[1] It may here be remarked that some cases of ligation of the internal jugular vein have been incorrectly reported. Thus M. Velpeau gives Professor Miller, of Kentucky, the credit of having cured a patient by the ligature; whereas that gentleman ligated the primitive carotid and suppressed the venous hemorrhage by compression. Professor Henry Smith, of this city, states, in his work on surgery, that the late Dr. Randolph tied the internal jugular during the extirpation of the parotid gland. The external jugular was the vessel involved. I have been very careful to avoid such errors by referring to the original reports, which have in most instances been accessible.

CASE IV.—Mr. Samuel Cooper has recorded a remarkable and unique case of death from primary subcutaneous hemorrhage. The patient, a soldier, had been shot, the ball entering behind the mastoid process, and passing downwards and forwards towards the sternum. The internal jugular was divided; the man lived for more than an hour, but was suffocated by the pressure of the large mass of extravasated blood on the trachea. (*First Lines of the Practice of Surgery*, vol. i. p. 529. New York, 1822.)

II. *Cases Fatal from the Introduction of Air.*—Wounds of this vein have been attended with the introduction of air in eleven instances, four of which were fatal. The cases of Wattman, Asmus, Brodie, and Morton, recovered, as will be seen in table No. II., although ligatures were applied to the vein. The case of Dr. Smith recovered from the effects of air, but died of exhaustion on the tenth day. The cases of MM. Velpeau and Bégin, referred to under the head of treatment by compression, resulted in a prompt cure. In ten of these cases the vein was injured during the removal of tumours, and in the eleventh the vessel had been divided in a suicidal attempt. It will thus be observed that the introduction of air was, in every case, the result of an incised wound, and after a very careful examination of a large collection of works on military surgery, I can safely state that there is not a single recorded instance of death from this accident following a gunshot injury.

In the following fatal cases, death occurred, in two, almost instantaneously; in one, in three hours and a half; and, in the fourth, after the lapse of seven days:—

CASE I.—Dr. Ulrich, of Berlin, 1834, divided the internal jugular in removing a tumour from the side of the neck. Not a drop of blood flowed, although the vessel remained patulous, and the assistants heard a whizzing sound. Soon, however, frothy blood welled from the inferior extremity; syncope ensued, with convulsive movements of the face and opisthotonos. The countenance became pale, the pulse small and tremulous, the respiration slow, and the man died at the expiration of a minute. On dissection, fifty-two hours after death, the vein was found imbedded in the tumour and obliterated a little above the point of its division. The right auricle was elastic and distended, and contained no blood. The blood of the right ventricle was fluid and black. (*Compendium de Chirurgie Pratique.* Par MM. Bérard et Denonvilliers, vol. i. p. 80. Paris, 1840.)

CASE II.—M. Gorré, of Bologne, 1842, in the removal of a cancerous growth of the left side of the neck, when he was dividing the last attachments, heard an unmistakable *glouglou.* The patient grew pale, the breathing was accelerated, and he died in about one minute. A post-mortem examination was made at the expiration of twenty-four hours, when the internal jugular was found to be opened about eight lines above the clavicle. The wound was oblique, about three lines long and gaping, and on compressing the vein from below upward, gave issue to spumous blood. The right auricle and ventricle, the superior vena cava, subclavian, axillary, brachial, and superficial veins of the brain contained blood mixed with air. (*Annales de la Chirurgie Française et Etrangère*, vol. vi. p. 305.)

CASE III. M. Mirault, of Angers, 1837, wounded the internal jugular, whilst separating a fibrous tumour of the right side of the neck from its deep connections. A whizzing sound was distinctly heard. repeated in a few seconds, when the face became livid, and there was a general trembling, with tetanic convulsions. The wound was filled with black blood, and the patient had ceased to respire. A ligature was thrown around the vein, and, after the lapse of eight minutes, under appropriate measures, the patient completely recovered and the operation was finished, about eight ounces of blood having been lost. The vein had been divided to the extent of one-half of its calibre, about an inch and a half above the clavicle. The patient was placed in his bed; his voice was weak, and his respiration a little lowered. Intense chilly sensations soon came on, and, at the end of three hours, M. Mirault found him presenting all the signs of suffocation, in which condition death ensued in about ten minutes. An autopsy was denied. (*Comp. de Chir. Pratique*, vol. i. p. 80.)

CASE IV.—M. Roux, 1832, divided the internal jugular in the removal of a tumour from the parotid region. Air was heard to enter the vein with a whistling sound, the breathing became much embarrassed, and the patient, a girl, was strongly convulsed. The vein was compressed, and, under the use of stimulants, she shortly recovered. Two ligatures were thrown around the tumour, which was not extirpated at the time, but on the sixth day, having become disintegrated, it was easily removed. On the following evening she died in a state of coma. On post-mortem inspection the internal jugular was found to be divided, the cavities of the heart were empty, and the aorta and iliac arteries contained air. The venous system presented no abnormal appearances. (*Gazette Médicale*, 1833, p. 498.)

Gunshot wounds of the internal jugular, if not immediately fatal, as they are very apt to be, are exceedingly liable to be followed by secondary hemorrhage and pyæmia, which usually terminate in death. In fact, I have not met with a single example of these injuries where the vein alone was involved, followed by recovery. Five of the seven cases here recorded proved fatal from secondary bleeding, in a period varying from four to fifteen days, and two died of purulent infection.

III. *Cases of Gunshot Wound Fatal from Secondary Hemorrhage.*

CASE I.—In April, 1849, Dr. Stromeyer had a case of gunshot fracture of the lower jaw, the bullet entering near the chin on the left side, and driving the spicula deep into the throat. "When I first saw him he was in imminent danger of suffocation, from which I freed him, by removing, by means of the left index finger introduced into the mouth, many large and sharp fragments from the neighbourhood of the larynx. He died suddenly on the fourth day, in the presence of his attending physician, a thick stream of dark blood issuing from the mouth." Warm poultices had been substituted for cold applications contrary to Dr. Stromeyer's orders. The autopsy showed an opening in the internal jugular vein, made by a splinter of bone, which still remained in it. (*Maximen der Kriegsheilkunst*, 2d edit. p. 131. Hanover, 1861.)

CASE II.—Professor Langenbeck relates the case of a young man, who was shot in a duel with pistols. The ball, which entered the mouth from right to left, shattered two teeth, broke the ramus of the jaw, and was perceptible on the left side of the neck. A copious hemorrhage of short duration followed. On the eighth day, secondary hemorrhage by the mouth suddenly carried the patient off: on inspection of the body, the left internal jugular was found to be torn. (*Archiv für Klinische Chirurgie*, vol. i. p. 22. Berlin, 1860.)

CASE III.—Dr. Hennen has recorded the following case: "A soldier of the Brunswick Oels., was struck at Waterloo by a musket ball on the tip of the nose, which split upon the bony edge where it is joined by the cartilage. A piece of the ball was extracted upon the spot, and it was supposed that the ball itself had been purposely cut into pieces, as is sometimes done by foreign riflemen. On the 10th day the man was seized with a violent hemorrhage from the mouth and nose, which came on suddenly, and carried him off in the course of the night. On dissection, it appeared that a very minute portion of the ball had penetrated along the basis of the skull, lodged in the sinus of the left internal jugular vein, forming a sort of sac for itself close upon the vein, which, having inflamed the coats of the vessels, at last ulcerated and burst. The case occurred in the practice of my friend Dr. Pockels, now Surgeon-in-chief of the troops of Brunswick." (*Principles of Military Surgery*, p. 90. New York, 1830.)

CASE IV.—M. Jobert de Lamballe, treating of gunshot wounds of the neck, mentions a case of M. Delpech, who cured a man of wound of the primitive carotid, too low down to be tied. Secondary hemorrhage ensued, and Delpech employed Valsalva's treatment. The patient was bled very frequently, and ultimately recovered. "In a similar case, I imitated Delpech. Indeed, I was congratulating myself upon having followed his example in a man who, in the disturbances of July, was shot, the ball wounding the primitive carotid and the internal jugular vein of the right side. Venesection frequently repeated had already notably diminished the amount of blood which escaped from the wound at different times: fifteen days had elapsed since the reception of the wound; I had great hopes; but in consequence of a violent effort on the part of the patient, a frightful hemorrhage produced death." (*Plaies d'Armes à Feu*, p. 159. Paris, 1833.)

CASE V.—"A wound from firearms proved fatal in fifteen days; the autopsy disclosed a communication between the internal jugular vein and the carotid artery. The ball was underneath and in the jugular itself. I have seen the specimen." (Prof. Velpeau. *New Elements of Operative Surgery*, vol. i. p. 860. New York, 1856.)

IV. *Cases of Gunshot Wound Fatal from Pyæmia.*

CASE I.—Dr. Schwarz met with a case in which a rifle ball had entered the mouth, shattered the left lower jaw, and penetrated the neck, tearing the internal jugular vein to the extent of a few lines. The missile remained at the opening of the vein, and therefore permitted the escape of only a few ounces of blood into the surrounding tissues. It was not removed, although it was felt in the swelling. Suppuration ensued, with death from pyæmia.

An autopsy showed a completely healed rent in the outer wall of the vein, the cylinder of which was slightly diminished but free. At the cicatrice the coats of the vein were thickened by plastic deposits, and a very adherent, semi-organized layer of lymph coated the lining membrane. The small veins in the neighbourhood of the abscess, in which the ball lay, were filled with broken-down coagula. (*Archiv für Klinische Chirurgie*, vol. i. p. 23.)

CASE II.—On the taking of Colding, Dr. Stromeyer saw a Schleswig-Holstein soldier who had been shot in the right side of the lower jaw in front of the insertion of the masseter muscle. The ball found its way under the tongue and the left side of the lower maxilla, behind the sterno-cleido-mastoid muscle, where it was felt on a level with the top of the larynx, but was not removed. There had been no hemorrhage. The patient died at the expiration of three weeks of pyæmia.

On the autopsy, an abscess was found behind the left sterno-cleido-mastoid muscle, in which lay the flattened bullet near to the vertebral column. "The internal jugular vein had been torn to the extent of five lines on its anterior and outer aspect; but the rent was completely healed, as the coats of the vein had applied themselves to it behind, and were united, so that the cylinder of the vessel was diminished one-half." (*Maximen der Kriegsheilkunst*, p. 132.)

V. *Cases of Incised and Punctured Wounds Fatal from Pyæmia.*

CASE I.—A boy, four years of age, on the 25th of November, 1834, fell upon the blade of a penknife, which entered his neck over the seat of the great vessels, just back of the thyroid cartilage. Dr. Bartlett saw him about five minutes after the accident, and found venous blood flowing in a full stream, the quantity lost, by estimation, being ten ounces. The bleeding was arrested by a moment's compression with the finger, and nothing more was done than to apply a bit of adhesive plaster. On the 29th. the neck was tender to the touch and a little swollen. The boy was restless and feverish, and he was placed upon the use of the antimonial and saline mixture, and a lotion of alcohol and water was applied to the neck. Dec. 1st. Had been leeched. At 10 A. M. had a severe chill, short, quick breathing, and frothing at the mouth; low, muttering delirium during the night; lips dry and some sordes on the teeth. Dec. 3d, 10 P. M. Death during a paroxysm of chills.

On dissection it was found that the internal jugular had been penetrated by the knife. Between the vertebræ and the sheath of the vessels an abscess had formed, containing six ounces of pus, and extending from an inch above the wound as low down as the clavicle. Coagulated blood was found in the sheath as low down as the pericardium. The wounds in the vein were closed by adhesive inflammation, and the cylinder of the vessel was so much contracted at that point, as to admit of the passage of a little more than an ordinary probe. "For the space of two inches below the wound, there was some appearance of ulceration within the vein; and it contained a firm, strong white cord of coagulum, extending from the wound into the right ventricle of the heart. This was so large as nearly to fill the jugular vein, and in many places adhered pretty firmly to it. The third or half of the pericardium next the base of the heart, showed marks of high inflammation." (*Amer. Jour. Med. Sci.*, Aug. 1835, p. 357.)

Case II.—M. Tacheron reports the case of a woman who was stabbed with a poniard in the root of the neck. Profuse hemorrhage ensued, and a tumour of the size of an egg, formed. Symptoms of pyæmia set in, and death occurred on the fifteenth day. The autopsy disclosed an abscess behind the carotid and internal jugular, and the latter presented a round opening, two lines in diameter, in its posterior wall. At this point a yellow fibrinous clot obliterated the interior of the vessel, and the clot, which contained a puriform fluid, extended down the jugular into the right auricle, where it expanded into a rose-colored and organized coagulum. Pleurisy existed on the left side. (*Gaz. Méd.*, p. 203. 1837.)

Case III.—Specimen 1521^{55} of the Museum of Guy's Hospital, London, shows a "jugular vein, exhibiting a wound occupying about half its circumference, and situated about half an inch above the subclavian; the neighbouring branches showing effects of phlebitis."

"James F., aged 30, under Mr. Birkett. He received a stab with a knife on the left side of the neck, piercing the sterno-cleido-mastoid muscle near its origin, by which the jugular was wounded. Much hemorrhage followed and continued for several days, when symptoms of phlebitis set in, and he died of pneumonia twenty days after the accident. The vein was found wounded as here seen, its coats infiltrated with lymph, and the interior filled with fibrin; lungs filled with abscesses." (*Catalogue of the Pathological Preparations of the Museum of Guy's Hospital.* Edited by Dr. Wilks, vol. i. London, 1863.)

VI. *Cases of Wounds Fatal from Other Causes.*—In addition to the above-mentioned observations, two additional cases are recorded of wounds of the internal jugular vein, in both of which neither secondary hemorrhage nor pyæmia was the cause of death.

Case I.—Professor Gross, on the 14th of September, 1846, was called to a lad fourteen years of age, of a scrofulous constitution, who had been wounded by the accidental discharge of a fowling-piece, a portion of the load, which consisted of large squirrel shot, entering the neck at four or five different points. The wounds were attended with little hemorrhage, and the patient soon recovered from the shock. For a time everything progressed favourably; the wounds of the neck healed without any application, when suddenly, thirteen days after the accident, and without any premonitory symptoms, the patient was seized with a protracted epileptic convulsion, chiefly affecting the left side, and died the following day without any return of consciousness.

Autopsy.—The shot which had entered the region of the right jugular and carotid, had perforated the anterior wall of the former vessel, and lodged on the inner surface of the opposite wall, where it had become completely encysted. The vein bore no evidence of inflammation; its cavity, however, was somewhat diminished by the projecting cyst; the opening in front was perfectly closed, and there was no external nor internal clot.

A shot had perforated the trachea and œsophagus, and was imbedded in the cartilage between the third and fourth cervical vertebræ. The openings were closed, with the exception of the one in the posterior wall of the œsophagus, which was separated from the spine by an abscess extending from the second to the seventh cervical vertebræ, and containing six drachms of scrofulous pus. One shot had perforated the subclavian artery and lodged in the first rib. The calibre of the vessel was unimpaired, and the openings were closed by small clots extending around the outside of the vessel, upon the removal of which the margins of the wounds appeared as if they had just been inflicted. The artery presented no marks of inflammation. The brain and spinal cord were free from morbid appearances, except a little serum in the lateral ventricles of the former. (*Amer. Journ. Med. Sciences*, p. 355. April, 1848.)

CASE II.—Dr. John H. Packard narrates the case of a man twenty-six years of age, of intemperate habits, who was admitted into the Pennsylvania Hospital on the 3d of November, 1855. He had been stabbed ten hours previously just below and behind the left ear, and was covered with blood. The hemorrhage had, however, ceased, and a tumour with much ecchymosis had formed. Cold water was applied, and five days subsequently there was some bleeding from the wounds and the tumour was found to be the seat of pulsation and somewhat diminished in size. On the 10th, Dr. Norris ligated the common carotid with the effect of arresting the pulsation; and on the 19th erysipelas set in, but subsided in a week. Death ensued from softening of the brain on the 6th of December.

A post-mortem inspection showed a sac occupied by a clot of blood in front of the upper cervical vertebræ, on the inner surface of which were three openings, the largest being that of the distal extremity of the divided internal jugular vein, while the other two corresponded to the almost divided occipital artery. The vein was much contracted and perfectly occluded for about half an inch on the cardiac side of the sac, and the common carotid artery was plugged up with firm coagula. The brain was somewhat softened throughout, with effusion into the ventricles. The cerebral tissue of the superior and anterior portion of the left hemisphere and of the posterior portion of the right hemisphere was broken down into a pasty mass. (*Amer. Journ. Med. Sciences*, p. 396. April, 1856.)

REMARKS.—The foregoing twenty fatal cases present many points of interest, and demonstrate that wounds of the internal jugular vein are by no means to be considered necessarily mortal from primary hemorrhage, that issue having occurred in but twenty per cent. of the cases. In one of these death was almost instantaneous, the vein having been divided to the extent of one-half its calibre. In the second, the patient lived a little more than an hour, the wound having been oblique and gaping, and of about three lines in extent. In the third, both veins and the left carotid were wounded, resulting in instantaneous death; and in the fourth, the vein was completely divided, and the hemorrhage proved fatal in one hour.

Of the cases in which the introduction of air into the circulation was the cause of death, the first and second were fatal in one minute, the vein, in one, having been completely divided, in the other it was opened to the extent of three lines. In the third case, the patient died in three hours and a half, the calibre of the vein having been divided one-half; and in the fourth, there was complete division with a fatal issue on the seventh day. Secondary hemorrhage, as a result of gunshot wounds, occurred in the five cases, respectively, on the fourth, eighth, tenth, and in two, fifteenth day.

Pyæmia resulted from gunshot wounds in two cases, one on the twenty-first day, the date of the other not being given. It was also the cause of death in three instances of incised wounds, on the eighth, fifteenth, and twentieth days respectively.

In the remaining two cases, the fatal issue was due, in one, to epilepsy, in the other to softening of the brain from ligation of the carotid artery.

Primary hemorrhage was prevented in the first case of Dr. Stromeyer by a splinter of bone, which had been driven into the vessel, and formed a mechanical obstacle to the flow of blood until loosened by suppuration. In the patient of Dr. Schwarz there was no external bleeding, the ball remaining at the opening of the vein, permitting the escape of but a few ounces of blood into the surrounding tissues. In Dr. Stromeyer's second case there was no hemorrhage, but had the ball been removed by incision, the patient would have been exposed to this danger as well as to the introduction of air. In the case of M. Velpeau the ball was partly in the vein, and in the absence of a satisfactory history we may presume that death resulted from secondary bleeding.

That *spontaneous union* of the lips of the wound, by the efforts of nature alone, may occur, is beautifully illustrated by the case of Professor Gross, which is rendered more interesting from the fact of the shot having become encysted in the interior of the vessel. In Dr. Schwarz's case, fatal from pyæmia, the rent in the vessel, of several lines in extent, had completely closed. At the cicatrice, the coats of the vein were thickened by plastic effusion, and a semi-organized layer of lymph was deposited on the lining membrane. The case of Dr. Bartlett showed the wounds healed, but the cavity of the vessel nearly obliterated; and the case of Dr. Stromeyer is interesting from the mode of healing, the wound, five lines long, adhering to the posterior and inner surface of the vessel, diminishing its calibre one-half.

In all these cases an abscess was present posterior to the sheath of the vessels, and in front of the cervical vertebræ.

For convenience of reference the foregoing cases are presented in the annexed table, from which it will be perceived that the causes of death were in the following ratio: introduction of air, 20 per cent.; primary hemorrhage, 20 per cent.; pyæmia, 25 per cent.; secondary hemorrhage, 25 per cent.; and other causes, 10 per cent.

TABLE I.—*Fatal Cases of Wounds of the Internal Jugular Vein.*

Case.	Surgeon.	Authority.	Cause of death.	Period of death.	Injury and extent of wound of vessel.	Vein affected.
1	Vallée,	Gaz. Méd. de Paris, p. 269. 1837	Primary hemorrhage	Instantaneous	Almost complete division; stab in neck	Right jugular.
2	Bryant,	Trans. Path. Soc. London, vol. viii. p. 101. 1857	Primary hemorrhage	1 hour and 5 minutes	One-fourth of an inch. Fall on broken china	Right jugular.
3	Gray,	Holmes System of Surgery, vol. ii. p. 277. London, 1861	Primary hemorrhage	Instantaneous	Incised in suicide; both veins & left carotid artery	Both jugulars.
4	S. Cooper,	Practice of Surgery, vol. i. p. 529. New York, 1822	Primary hemorrhage and suffocation from pressure on trachea	A little more than an hour	Complete division; gunshot wound	
5	Ulrich,	Compendium de Chir. Pratique, vol. i. p. 80. Paris, 1840	Introduction of air	1 minute	Complete division in removal of tumour	
6	Gorré,	Annal. de la Chirurgie Française et Etrangère, vol. vi. p. 305	Introduction of air	1 minute	Three lines and oblique. Removal of tumour	Left jugular.
7	Mirault,	Comp. de Chir. Prat., vol. i. p. 80	Introduction of air	3½ hours	Half its calibre in removal of tumour	Right jugular.
8	Roux,	Gaz. Médicale, 1833, p. 498	Introduction of air, coma	7 days	Complete division in removal of tumour of neck	
9	Stromeyer	Max. der Kriegsheilkunst, 2d ed., p. 131. Hannover, 1861	Secondary hemorrhage	4th day	Gunshot splinter of bone driven into vessel.	Left jugular.
10	Langenbeck	Archiv für Klin. Chir., vol. i. p. 22. Berlin, 1860	Secondary hemorrhage	8th day	Gunshot; vein torn	Left jugular.
11	Hennen,	Princip. of Mil. Surg., Am. ed., p. 90. New York, 1830	Secondary hemorrhage	10th day	Gunshot, followed by ulceration	Left jugular.
12	Jobert de Lamballe	Plaies d'Armes a Feu, p. 159. Paris, 1833	Secondary hemorrhage	15th day	Gunshot, involving common carotid artery	Right jugular.
13	Velpeau,	Operative Surg., Am. ed., vol. i. p. 80. New York, 1856	Secondary hemorrhage	15th day	Gunshot, involving common carotid	
14	Schwarz,	Archiv für Klin.-Chir., vol. i. p. 23	Pyæmia	....	Gunshot	Wound of vein had united.
15	Stromeyer,	Maxim. der Kriegsheilkunst, p. 132. Hannover, 1861	Pyæmia	21st day	Gunshot, five lines	Left jugular, wound united.
16	Bartlett,	Am. Jour. Med. Sci., vol. xvi. p. 357. 1835	Pyæmia	8th day	Punctured by penknife	Wound united.
17	Tacheron,	Gaz. Médicale, 1837, p. 203.	Pyæmia	15th day	Stab with poniard; two lines	Wound open.
18	Birkett,	Catalogue of the Pathological Preparations of the Museum of Guy's Hospital, vol. i. London, 1863	Pyæmia	20th day	Stab with a knife; half of circumference	Left jugular, wound open.
19	Gross,	Amer. Jour. Med. Sci., April, 1848, p. 355	Epilepsy	14th day	Punctured by small shot	Right jugular, wound united.
20	Packard,	Amer. Jour. Med. Sci., April, 1856, p. 396	Softening of the brain	33d day	Stab, involving occipital artery	Left jugular, wound open.

Arterio-Venous Aneurism of the Internal Jugular Vein.—Wounds of the internal jugular vein, when complicated with similar injuries of the carotid artery, do not always prove fatal, either at once or secondarily, but may result, under favourable circumstances, in the formation of arterio-venous aneurisms. The prognosis of these cases is less serious than when the artery alone has been injured, as a portion of the blood of the latter penetrates the vein; a tumor composed of effused blood forms in the surrounding tissues, and the hemorrhage is arrested, and the cure effected by the almost unaided efforts of nature. I have been able to collect nine examples of this affection, seven being referable to aneurismal varix, and two to varicose aneurism. In five the communication existed between the primitive carotid artery and internal jugular vein, and in four between the latter and the internal carotid. In none did the affection appear to shorten life, or produce much inconvenience. In the cases of Baron Larrey—the first on record—as well as in the one narrated by Dr. Marx, the formation of the aneurismal varix was favoured by the mode of production of the wound; they were the result of sword thrusts which divided the sterno-cleido-mastoid muscle in the direction of its fibres, so that when the weapon was withdrawn, the wounds did not gap. In all the cases syncope from loss of blood, by favouring the coagulation of that fluid, materially added to the fortunate issue.

Case I.—A sub-officer, on the 23d of September, 1821, was wounded by a short sword immediately above the sterno-clavicular articulation. The sternal origin of the sterno-cleido-mastoid muscle had been cut in a longitudinal direction, to the extent of half an inch, and the right internal jugular vein and primitive carotid artery, near its origin from the innominate, had been punctured. A very copious hemorrhage ensued, and the surgeon of the corps with difficulty arrested it.

The patient was brought to the hospital and the dressings were carefully removed. Baron Larrey found the edges of the wound agglutinated by a black coagulum, and a pulsating tumour had formed, of the size of the fist, accompanied with a peculiar bruit. The man was speechless, weak, and pale, and in a state of stupor. The wound was dressed with adhesive strips, and covered with a bladder filled with ice.

In the evening the pulse and warmth of surface had returned; the external jugular vein pulsated and was much enlarged; and the man was bled from the arm. On the fifth day the pulse was very frequent, and there was intense cephalalgia, for which the temporal artery was opened, and leeches applied to the nucha and between the shoulders. On the tenth day the tumour began to diminish, and had disappeared on the sixtieth day after the accident, when he returned to duty. The varix, however, remained. The treatment consisted in repeated withdrawals of blood by opening a vein and by leeches, in the continuous application of ice to the tumour, and the exhibition of cooling drinks. (*Clinique Chirurgicale*, vol. iii. p. 149. Paris, 1829.)

Case II.—This case was analogous to the preceding. The man entered the hospital, April 5th, 1822, to be treated for a small wound on the lower portion of the right side of the neck, accompanied with an ovoidal tumour of an aneurismal nature. Both resulted from simultaneous perforation of the walls of the jugular vein and the carotid artery, produced by a sabre thrust. The symptoms were not so well marked as in the preceding case, on account of the arterial lesion being smaller. The treatment was precisely similar, and the man returned to duty at the expiration of two months. (Ibid., p. 154.)

Case III.—A gentleman was wounded in a duel, the point of the sword entering above the inner end of the right clavicle, and inflicting a wound half an inch long. Arterial blood escaped in a full and continuous jet, which the patient himself arrested by placing several folded handkerchiefs over the cut and retaining them in position by another carried around the neck. He walked to a hospital in the vicinity, which required thirty minutes; but on his way, feeling weak, he stopped at a tavern to take a glass of wine, where he fell into a state of partial syncope. When he arrived at the hospital, the surgeon brought the edges of the wound together with adhesive strips, and placed him on a rigorous diet. At the expiration of five days the wound had united, and the patient returned home, with a small pulsating tumour, attended with a bruit. It gradually disappeared and gave him no inconvenience.

Twenty years after the accident, Dr. Marx presented the man to the Academy of Medicine, when he had all the signs of an aneurismal varix. (*Mémoires sur l'Anéurysmes.* Par M. Breschet. *Mémoires de l'Académie Royale de Médecine*, vol. iii. p. 233. Paris, 1833.)

CASES IV.-V.—Two other cases of traumatic aneurismal varix of the common carotid and internal jugular vein are recorded: one by Williamson,[1] the result of a sabre wound above the clavicle; the other by Rigaud,[2] the lesion having been produced by a very fine splinter of glass.

CASES VI.-IX.—MM. Joret, Desperanches, A. Bérard, and Giraldès have each observed a case of arterio-venous aneurism between the internal jugular vein and common carotid artery; and in two of the cases in which an autopsy was held, an aneurismal sac existed between the vessels. The wound was produced in two cases by a ball, in one by a particle of lead, and in the fourth by a shoemaker's knife. In the case of M. Giraldès the projectile was found in the aneurismal sac.[3]

In the next number of this journal the subject of this paper will be completed, by some observations on the treatment of wounds of the internal jugular vein for the arrest of hemorrhage, and the prevention of the introduction of air.

PHILADELPHIA, October, 1866.

ART. II.—*On Internal Aneurism, and its' Relation to Sudden Death, with an account of ten cases in which the existence of that disease was not suspected prior to the death of the subject, from rupture of the sac; to which is appended a Practical Discussion concerning the Diagnosis and Treatment of Aortic Aneurism.* By JOHN A. LIDELL, M. D., of New York.

IN the time of our predecessors, when a person in full flesh, and seemingly free from disease of any serious nature, happened to fall down suddenly, without apparent cause, and immediately expire, it was usually said that the death was occasioned either by *apoplexy*, or by *disease of the heart.* Indeed, the term apoplexy had its origin far back in Grecian antiquity, in one of the most striking of the circumstances mentioned above; for the victims of that disease generally fall down suddenly, as if stricken by a powerful blow. But pathological investigations of an anatomical character, especially those of a recent date, have abundantly shown that there are other causes of sudden death, unconnected with wound, or violence, or poison, besides the anatomical lesions of the brain and heart, and that

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[1] Sabatier par Dupuytren. De la Méd. Opér., vol. iii. p. 188. Paris, 1832.
[2] Follin. Traité Elémentaire de Path. Ext., vol. ii. p. 411. Paris, 1863.
[3] Ibid., p. 413.